View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Repositorio da Producao Cientifica e Intelectual da Unicamp

UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

MARINA DOS SANTOS FARIA

AVALIAÇÃO DA INFLUÊNCIA DO REEMBASAMENTO COM RESINA COMPOSTA E PROTOCOLOS DE CIMENTAÇÃO SOBRE A RESISTÊNCIA AO CISALHAMENTO POR EXTRUSÃO DE RETENTORES INTRARRADICULARES DE FIBRA DE VIDRO.

EVALUATION OF THE INFLUENCE OF RELINING WITH COMPOSITE RESIN AND CEMENTATION PROTOCOLS ON THE SHEAR RESISTANCE PER PUSH-OUT OF FIBERGLASS INTRARADICULAR POSTS

Piracicaba

2018

MARINA DOS SANTOS FARIA

AVALIAÇÃO DA INFLUÊNCIA DO REEMBASAMENTO COM RESINA COMPOSTA E PROTOCOLOS DE CIMENTAÇÃO SOBRE A RESISTÊNCIA AO CISALHAMENTO POR EXTRUSÃO DE RETENTORES INTRARRADICULARES DE FIBRA DE VIDRO.

EVALUATION OF THE INFLUENCE OF RELINING WITH COMPOSITE RESIN AND CEMENTATION PROTOCOLS ON THE SHEAR RESISTANCE PER PUSH-OUT OF FIBERGLASS INTRARADICULAR POSTS

Dissertação apresentada à Faculdade de Odontologia Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Mestra em Clínica Odontológica, na Área de Dentística.

Dissertation presented to the Piracicaba Dental School, University of Campinas in partial fulfillment of the requirements for the degree of Master in Dental Clinics, in Operative Dentistry.

Orientador: Prof. Dr. Luís Roberto Marcondes Martins

ESTE EXEMPLAR CORRESPONDE À VERSÃO FINAL DA DISSERTAÇÃO DEFENDIDA PELA ALUNA MARINA DOS SANTOS FARIA, E ORIENTADA PELO PROF. DR. LUÍS ROBERTO MARCONDES MARTINS.

Piracicaba

2018

Agência(s) de fomento e nº(s) de processo(s): Não se aplica.

Ficha catalográfica
Universidade Estadual de Campinas
Biblioteca da Faculdade de Odontologia de Piracicaba
Marilene Girello - CRB 8/6159

F225a

Faria, Marina dos Santos, 1992-
Avaliação da influência do reembasamento com resina composta e protocolos de cimentação sobre a resistência ao cisalhamento por extrusão de retentores intrarradiculares de fibra de vidro / Marina dos Santos Faria. – Piracicaba, SP : [s.n.], 2018.

Orientador: Luís Roberto Marcondes Martins.
Dissertação (mestrado) – Universidade Estadual de Campinas, Faculdade de Odontologia de Piracicaba.

1. Adesivos dentinários. 2. Cimentos dentários. 3. Resistência ao cisalhamento. I. Martins, Luís Roberto Marcondes, 1960-. II. Universidade Estadual de Campinas. Faculdade de Odontologia de Piracicaba. III. Título.

Informações para Biblioteca Digital

Título em outro idioma: Evaluation of the influence of relining with composite resin and cementation protocols on the shear resistance per push-out of fiberglass intraradicular posts
Palavras-chave em inglês:
Dentin-bonding agents
Dental cements
Shear strength
Área de concentração: Dentística
Titulação: Mestra em Clínica Odontológica
Banca examinadora:
Luís Roberto Marcondes Martins [Orientador]
Giselle Maria Marchi Baron
Milena Maria Pierre Santos Caldeira
Data de defesa: 16-02-2018
Programa de Pós-Graduação: Clínica Odontológica

UNICAMP

UNIVERSIDADE ESTADUAL DE CAMPINAS
Faculdade de Odontologia de Piracicaba

A Comissão Julgadora dos trabalhos de Defesa de Dissertação de Mestrado, em sessão pública realizada em 16 de Fevereiro de 2018, considerou a candidata MARINA DOS SANTOS FARIA aprovada.

PROF. DR. LUÍS ROBERTO MARCONDES MARTINS

PROFª. DRª. MILENA MARIA PIERRE SANTOS CALDEIRA

PROFª. DRª. GISELLE MARIA MARCHI BARON

A Ata da defesa com as respectivas assinaturas dos membros encontra-se no processo de vida acadêmica do aluno.

DEDICATÓRIA

A Deus, por ter me feito sua imagem e semelhança e que sem Ele nada eu seria.

A minha mãe, Maria Aparecida dos Santos, meu grande amor e maior exemplo e que esteve do meu lado nos momentos mais difíceis me mostrando que tudo tem um proposito e não me deixando desistir.

Ao meu pai, Ivair Gomes Faria, que mesmo já falecido é a luz para meus dias mais escuros.

A minha família, avós Elza e Otávio, padrasto Luiz Carlos Martins e todos os membros que sempre me apoiaram e acreditaram em mim.

AGRADECIMENTO ESPECIAL

Ao Prof. Dr. Luís Roberto Marcondes Martins pela sua orientação, proporcionando-me meu crescimento acadêmico e pessoal. Sendo um exemplo de profissional, pessoa e amigo que me incentiva a ser uma pessoa e profissional melhor.

AGRADECIMENTOS

A minha mãe, Maria Aparecida dos Santos, pois somente ela que presenciou todos meus momentos, e todo o esforço que fiz pra conseguir fazer esse mestrado. Além de ter sido ela que me deu forças e os meios para ir até o fim dessa jornada.

Ao meu padrasto, Luiz Carlos Martins, pelo seu apoio e dedicação comigo e com minha mãe.

Aos meus avós, Elza e Otávio, por todas as orações e horas de sono perdidas.

A minha amiga, Fernanda M. M. dos Reis, pela sua disposição em me ajudar e porque sem ela esse trabalho não teria saído.

As minhas outras amigas, Carol, Eloisa, Eloá, Dani, Rafinha, pelo encontro que me deu forças para seguir em frente e não desistir.

A minha amiga, Amanda N. Pires, pelo companheirismo e pelos momentos de distração.

A minhas amigas, Flávia Celtron e Marcia R. Peres, pela chance de conviver com ela todos os dias e pelos ensinamentos passados.

Aos meus amigos do mestrado, Rodrigo, Mariana, Josué, Maicon, Carol, Renata, Bruna, Maiara e Laura, pelo parceria e convivência nesses dois anos.

A doutoranda Cristiane R. F. Yanikian, por toda a ajuda, dedicação, disposição e orientação nesses anos.

A todos os professores do curso, pela oportunidade de poder aprender e crescer com eles, em especial a Profa. Dra. Glaucia Maria Bovi Ambrosano pela ajuda com a análise dos dados.

A Faculdade de Odontologia de Piracicaba, por ter sido minha segunda casa todos esses anos.

EPÍGRAFE

Treine enquanto eles dormem, estude enquanto eles se divertem, persista enquanto eles descansam, e então, viva o que eles sonham.

(Provérbio Japonês)

RESUMO

O uso de pinos de fibra de vidro associados a cimentos resinosos para restaurações estéticas já está consolidado na odontologia. Entretanto os protocolos instaurados na literatura apresentam várias etapas e há uma tendência de simplificação da Odontologia Restauradora, então protocolos com menos passos de cimentação é interessante clinicamente. Objetivo do estudo, então, foi avaliar os efeitos do reembasamento com resina composta e diferentes protocolos sobre a resistência à extrusão de pinos de fibra de vidro, por meio de um estudo experimental controlado e randomizado. Realizou-se um experimento em esquema fatorial de parcelas subdivididas. Os fatores de estudos foram: 1) técnica de cimentação, em 4 níveis: G1 e G5: Scoth Bond Multi-Purpose (SBMP) + RelyX ARC (ARC); G2 e G6: RelyX U200 (U200); G3 e G7: Single Bond Universal (SBU) self-etch + RelyX Ultimate (Ultimate); G4 e G8: OptiBond All-in-one self-etch + NX3 Nexus Third Generation (NX3); 2) reembasamento com resina composta, em 2 níveis: G1 a G4 sem reembasamento e G5 a G8 com reembasamento do retentor, e; 3) região da dentina radicular, em 3 parcelas: região cervical, média e apical. Após os protocolos de cimentação, foram confeccionado de 2 a 3 discos para cada região radicular. Os espécime passaram na máquina de ensaio universal INSTROM para ensaio mecânico de resistência ao cisalhamento por extrusão (push-out), até a falha. Os valores obtidos em kgf foram convertidos para MPa. E as amostras foram analisadas em microscópio óptico para classificação dos padrões de falha. Os resultados passaram por análise de variância em esquema de parcelas subdivididas realizadas no SAS, considerando o nível de significância de 5%. Os resultados encontrados foram de não houve diferença estatística quanto aos diferentes protocolos de cimentação sem reembase do pino de fibra de vidro, porém entre os grupos com reembasamento, o G8 apresentou os menores valores. Não houve diferença significativa quando comparados os grupos com ou sem reembasamento do pino com o mesmo protocolo de cimentação e mesma região da dentina radicular, com exceção dos grupos 1 e 5 na região cervical e média e dos grupos 3 e 7 na região apical. Já a região da dentina radicular interfere na resistência à extrusão nos grupos sem reembasamento e também no G5. Já o padrão de falha mostrou uma homogeneidade e mais falhas adesivas nos grupos sem reembasamento, enquanto que nos reembasados as falhas foram mais heterogêneas. Portanto, a hipótese de que um sistema adesivo dentinário universal associado ao cimento resino dual interfere na resistência à extrusão é falso. O reembasamento do pino de fibra de vidro apesar de não apresentar diferença significativa nos valores do push-out, mostra no padrão de falha maior resistência adesiva. E por último a hipótese de que a região da dentina radicular interfere na resistência à extrusão é verídica, tendo diferença entre as regiões e sendo a apical a com os menores valores.

Palavras-chave: Adesivos; Cimentos Dentários; Resistência ao Cisalhamento

ABSTRACT

The use of fiberglass intraradicular posts associated with resin cements for aesthetic restorations is already consolidated in Dentistry. However, the protocols introduced in the literature have several steps and the Restorative Dentistry has been simplified, so protocols with fewer cementation steps are clinically interesting. So, the objective of this study was to evaluate the effects of relining with composite resin and different protocols on the extrusion resistance of fiberglass posts, through a controlled and randomized experimental study. The experiment was in a factorial scheme of subdivided plots. The study factors were: 1) cementing technique, in 4 levels: G1 and G5: Scoth Bond Multi-Purpose (SBMP) + RelyX ARC (ARC); G2 and G6: RelyX U200 (U200); G3 and G7: Single Bond Universal (SBU) self-etch + RelyX Ultimate (Ultimate); G4 and G8: OptiBond All-in-one self-etch + NX3 Nexus Third Generation (NX3), e; 2) composite resin reline, in 2 levels: G1 to G4 without relining and G5 to G8 with relining of the post, and; 3) radicular dentin region, in 3 plots: cervical, middle and apical region. After the cementation, 2 or 3 discs were made for each region root region. The specimens were tested for shear strength by push-out until fracture using the universal test machine INSTROM. The values obtained in kgf were converted to MPa. After the push-out, the samples were analyzed under an optical microscope to classify the failure modes. The results were analyzed in subdivided plots by variance analysis performed by SAS, considering a 5% level of significance. The results were found to have not been statistical difference between different cementation protocols without relining of the fiberglass post, but among the groups with relining, group 8 had the lowest values. There was no significant difference between the groups with or without relining of the fiberglass post when the same cementation protocol was applied, except for the groups 1 and 5 in the cervical and middle region and groups 3 and 7 in the apical region. However, the root dentin region has shown to interfere in the extrusion resistance in the groups without post relining and in the group 5. Already, the failure modes showed a homogeneity and more adhesive failures in the groups without relining, whereas in the reline groups the failures were more heterogeneous. Therefore, the hypothesis that a universal dentin adhesive system associated with dual resin cement interferes with the push-out is false. The reline of the fiberglass post although not presenting significant difference in the values of the push-out, shows in the failure modes better adhesive strength. Finally, the hypothesis that the root dentin region interferes with the extrusion resistance is true, with a difference between the regions and the apical one with the worse values.

Descriptors: Adhesives; Dental Cements; Shear Strength

SUMÁRIO

INTRODUÇÃO

As restaurações de dentes com tratamento endodôntico têm sofrido significativas mudanças nos últimos anos[1]. A demanda por estética associada a resistência é algo importante para ser levado em consideração na escolha da restauração ideal no tratamento de dentes anteriores tratados endodonticamente [2]. Atualmente, o uso de retentores intrarradiculares de fibra de vidro associados com cimentos resinosos para restaurações estéticas vem sendo muito bem aceito e ganhando força [3].

Entretanto, a cimentação dos retentores intrarradiculares é um procedimento desafiador devido as características da dentina radicular após o tratamento endodôntico e das propriedades dos diferentes sistemas de união [4]. Vários fatores contribuem para que a cimentação seja crítica, entre eles o fato de que o canal radicular não permite o devido acesso da luz durante a polimerização do cimento resinoso, desse modo, causando uma falha na conversão dos monômeros resinosos nos primeiros minutos da cimentação [5]. Para que isso não ocorra os fabricantes desenvolveram sistemas adesivos capazes de acelerar o processo de polimerização inicial dos cimentos resinosos duais ou dos autopolimerizáveis através de primers e co-iniciadores, e com isso melhorar a retenção primária dos pinos de fibra de vidro nos condutos radiculares [6,7].

Além disso, a adesão entre os retentores intrarradiculares com os cimentos resinos, também precisa de atenção. Dentre os vários tratamentos de superfície e agentes de união que foram testados os silanos, mostraram-se o melhor método para a retenção do pino à resina composta do cimento por aumentar a estabilidade hidrolitica da interface pino/cimento [8,9,10]. Entretanto, a Odontologia Restauradora vem passando por uma fase de simplificação, então a utilização de uma quantidade menor de materiais na processo de cimentação é interessante clinicamente.

Hoje, existem os adesivos, denominados universais, que são diferenciados em sua composição química podendo ser utilizados tanto pelas técnicas com condicionamento ácido total prévio ou pela técnica autocondicionante [11,12]. Os sistemas adesivos simplificados, ou seja, que contém porções hidrófilas e hidrófobas num mesmo frasco, agem como membranas permeáveis para água, mesmo após a polimerização [13], além disso, os adesivos autocondicionantes de frasco único contém monômeros acídicos que permanecem na superfície da camada de adesivo [14]. Esses monômeros residuais reagem com as aminas terciárias dos compósitos de ativação química ou dual, reduzindo a quantidade de aminas para reagir com o peroxido de benzoíla, responsáveis pela iniciação da reação de polimerização química [15].

Para ser usados com os adesivos universais uma nova geração de cimentos resinosos também foi desenvolvida. Estes, possuem em sua composição um sistema compatível com a química dos adesivos ácidos, diminuindo a reação entre os monômeros residuais e as aminas terciárias dos cimentos resinosos.

Além disso, outro aspecto do sistema de retenção a ser levado em consideração é a anatomia radicular, afinal canais amplos acabam gerando uma camada excessivamente espessa de cimento resino, que acabam não sendo suficientemente resistente as forças oclusais [16,17]. O reembasamento do retentor intrarradicular com resina compostas pode evitar essa ampla linha de cimento resino, agregando ainda suas boas propriedades mecânicas ao pino de fibra de vidro [17]. Entretanto, as análises qualitativas desse tipo de pino são escassas na literatura.

Então, um estudo que associe todos os fatores descritos acima se faz necessário para avaliar todos os matérias novos disponíveis no mercado e suas diferentes formas de aplicação. Portanto, o objetivo deste estudo foi avaliar os efeitos do reembasamento com resina composta restauradora e diferentes protocolos de cimentação sobre a resistência à extrusão de pinos de fibra de vidro, por meio de um estudo experimental controlado e randomizado. As hipóteses confrontadas serão: 1) o uso de um sistema adesivo dentinário universal associado ao cimento resinoso dual interfere na resistência à extrusão; 2) o reembasamento do pino de fibra de vidro melhora a resistência à extrusão, e; 3) a região da dentina radicular interfere na resistência à extrusão.

ARTIGO

EVALUATION OF THE INFLUENCE OF RELINING WITH COMPOSITE RESIN AND CEMENTATION PROTOCOLS ON THE SHEAR RESISTANCE PER PUSH-OUT OF FIBERGLASS INTRARADICULAR POSTS

ABSTRACT

This study was to evaluate the effects of relining with composite resin and different protocols on the extrusion resistance of fiberglass posts, through a controlled and randomized experimental study. The study factors were: 1) cementing technique, in 4 levels: G1 and G5: Scoth Bond Multi-Purpose (SBMP) + RelyX ARC (ARC); G2 and G6: RelyX U200 (U200); G3 and G7: Single Bond Universal (SBU) self-etch + RelyX Ultimate (Ultimate); G4 and G8: OptiBond All-in-one self-etch + NX3 Nexus Third Generation (NX3), e; 2) composite resin reline, in 2 levels: G1 to G4 without relining and G5 to G8 with relining of the post, and; 3) radicular dentin region, in 3 plots: cervical, middle and apical region. So, 2 or 3 discs were made for each region root region. The specimens were tested for shear strength by push-out until fracture using the universal test machine INSTROM. After, the samples were analyzed under an optical microscope to classify the failure modes. The results were found to have not been statistical difference between different cementation protocols without relining of the fiberglass post, but among the groups with relining, group 8 had the lowest values. There was no significant difference between the groups with or without relining of the fiberglass post when the same cementation protocol was applied, except for the groups 1 and 5 in the cervical and middle region and groups 3 and 7 in the apical region. However, the root dentin region has shown to interfere in the extrusion resistance in the groups without post relining and in the group 5. Already, the failure modes showed a homogeneity and more adhesive failures in the groups without relining, whereas in the reline groups the failures were more heterogeneous. Therefore, the hypothesis that a universal dentin adhesive system associated with dual resin cement interferes with the push-out is false. The reline of the fiberglass post although not presenting significant difference in the values of the push-out, shows in the failure modes better adhesive strength. Finally, the hypothesis that the

root dentin region interferes with the extrusion resistance is true, with a difference between the regions and the apical one with the lowest values.

Descriptors: Adhesives; Dental Cements; Shear Strength

INTRODUCTION

The advancement in dental materials technology and increased aesthetic treatments demand turned the use of fiberglass posts and resin cements a common and well accepted practice.[1] However, cementation of intraradicular posts by the adhesive technique is critical. Mainly because there is a small access to light in the root canal during the resin cement polymerization. And this causes a deficiency in the resinous monomers conversion in the first minutes after cementation. [2] To avoid this undesirable effect, some manufacturers have developed adhesive systems containing primer and co-initiators to accelerate the initial polymerization process of the dual and self-curing resin cements and consequently to improve the primary retention of the fiber posts within the root canals.[3,4]

On the other hand, the adhesion of the fiberglass posts to the resin cement also deserves attention. Several surface treatments and bonding agents have been tested to determine the best method for retention of the fiber post to the cement’s composite resin and it is suggested that the use of silanes increases the hydrolytic stability of the post/cement interface.[5,6,7] However, there is a trend towards simplification in Restorative Dentistry, so the use of fewer products in the cementation system of the fiberglass posts is interesting from the clinical point of view.

Currently, there are on the market the simplified adhesives called universal which have a different chemical composition that can be used by the technique of total acid etching or as self-etching.[8,9] There is an incompatibility between its acid monomers with the dual resin cement. Simplified adhesive systems, i.e., containing hydrophilic and hydrophobic moieties in the same bottle, act as water permeable membranes even after polymerization.[10] In addition, one-bottle self-etching adhesives contain acidic monomers that remain on the surface of the adhesive layer.[11] These residual monomers react with the tertiary amines of the dual or chemical activation composites, reducing the amount of amines to react with the benzoyl peroxide, responsible for the initiation of the chemical polymerization reaction.[12]

A new generation of dual resin cement has also been developed for use with universal adhesives. These cements have a system that allows chemical compatibility with acidic adhesives, decreasing the reaction between the residual monomers and the tertiary amines of the resin cements.

And taking into account the entire retention system, the root anatomy also deserves attention. This is because broad root canals generate an excessively thick layer of resinous cement, which in turn are not strong enough to withstand the occlusal forces.[13,14] This wide line of cementation can be avoided by relining the fiber post with restorative composite resin, adding its good mechanical properties to the post. [14] However, the literature is scarce in relation to the qualitative analysis of this type of post.

Hence, it is necessary to study the association between all the factors described above to evaluate the new materials available in the market and its various forms of application. Therefore, the aim of this study was to evaluate the effects of relining with restorative composite resin and different cementation protocols on the fiberglass posts extrusion resistance by means of a randomized controlled experimental study. It is hypothesized that; 1, the use of a universal dentin adhesive system associated to a dual resin cement does not interfere in the push-out; 2, the reline of the fiberglass post improves the resistance to extrusion; and 3, the root dentin region interferes with the extrusion resistance.

MATERIALS AND METHODS

- Experimental design

The experiment was in a factorial scheme (4x2) of subdivided plots (cervical, middle and apical region). The study factors were; 1, cementing technique, in 4 levels; 2, composite resin reline, in 2 levels; and 3, radicular dentin region, in 3 plots. The response variable was the extrusion shear strength (MPa).

The materials used are detailed in Table 1.

Table 1. Materials used in this study.

Material	**Composition**	**Manufacturer**
Post	Fiberglass and epoxy resin	Exacto, Angelus, Londrina, Brazil
Composite resin	Bis-GMA, Bis-EMA e UDMA, Particles: silica/zirconia, Photoinitiator	Filtek Z250XT, 3M ESPE, St Paul, USA
Adhesive	Bis-GMA, HEMA and photoinitiator solution	Scotchbond Multi-Purpose, 3M ESPE, St Paul, USA
Silane	Pre-hydrolyzed silane	Rely X Ceramic Primer, 3M ESPE, St Paul, USA
Phosphoric acid	35% phosphoric acid, thickener	Ultra-etch, Ultradent, South Jordan, USA
Primer	Aqueous solution of HEMA and polyalkenoic acid copolymer	Scotchbond Multi-Purpose, 3M ESPE, St Paul, USA
Activator	Sulfinic acid salt, ethanol and photoinitiator	Scotchbond Multi-Purpose, 3M ESPE, St Paul, USA

Catalyst	Bis-GMA, HEMA and benzoyl peroxide	Scotchbond Multi-Purpose, 3M ESPE, St Paul, USA
Adhesive	MDP, glass ionomer copolymer, silane and photoinitiator	Single Bond Universal, 3M ESPE, St Paul, USA
Adhesive	GPDM, co-monomers including monomers methacrylates, nanosilica, photoinitiator	OptiBond All-in-one, Kerr Corporation, Orange, USA
Dual resin cement	Paste A: Bis-GMA, TEGDMA, zirconia and silica particles, pigments, amines and photoinitiator Paste B: Bis-GMA, TEGDMA, benzoyl peroxide and zirconia and silica particles	RelyX ARC, 3M ESPE, St Paul, USA
Dual resin cement	Paste A: Silane-treated glass powder, 2-propenoic acid, 2-methyl-, 1,1- [1-(hydroxymethyl) -1,2-ethanediyl] ester, reaction products with 2-hydroxy-1,3-propanediyl and DMA phosphorus oxide, TEGDMA, silane-treated silica, glass oxide chemicals, sodium persulfate, tert-butyl peroxy-3,5,5-trimethyl, copper (II) acetate monohydrate Paste B: Silane-treated glass powder, DMA substituted, DMA 1,12-dodecane, silane-treated silica, 1-benzyl-5-phenylbarbic acid, calcium salt, sodium	RelyX Ultimate, 3M ESPE, St Paul, USA

	p-toluenesulfinate, 2-propenoic acid, 2-methyl -, [(3-methoxypropyl) imino] di-2,1-ethanediyl ester, calcium hydroxide, titanium dioxide	
Dual resin cement	Base paste: Methacrylate monomers containing phosphoric acid groups, Methacrylate monomers, Silanated fillers, Initiator componentes, Stabilizers, Rheological additives Catalyst paste: Methacrylate monomers, Alkaline (basic) fillers, Silanated fillers, Initiator componentes, Stabilizers, Pigments, Rheological additives	RelyX U200, 3M ESPE, St Paul, USA
Dual resin cement	Uncured Methacrylate Ester Monomers, inert mineral fillers, activators and stabilizers and radiopaque agent	NX3 Nexus Third Generation, Kerr Corporation, Orange, USA

GMA, bisphenol-A-glycidyl dimethacrylate; Bis-EMA, ethoxylated bisphenol-A-glycidyl dimethacrylate; UDMA, urethane dimethacrylate; TEGDMA, triethylene glycol dimethacrylate; HEMA, hydroxyethyl dimethacrylate; GPDM: glycero-phosphate dimethacrylate.

- Test specimens preparation

Bovine teeth with straight root anatomy closed apex and free of cracks were previously selected, cleaned and disinfected in 0.5% thymol solution. Eighty roots were sectioned at 18mm length with a diamond disc (KG Sorensen, São Paulo, Brazil). The pulp tissue was removed with K type files (Dentsply-Maillefer, Tulsa, USA) under irrigation with 1.0% sodium hypochlorite to suspend the organic matter. The roots were numbered for later randomization and stored in distilled water at 37 ºC.

Endodontic treatment was performed manually with mechanical instrumentation using K files (Dentsply Maillefer, Tulsa, USA) and a 17mm working length. The apical stop was performed with a file 40. During the instrumentation process, the root canal was abundantly irrigated with distilled water, so that the irrigating solution does not characterize a confounding factor to the study. [15] Root canal obturation was performed with gutta-percha cones and Sealer 26 endodontic cement (Dentsply, Tulsa, USA). Then, the roots were stored in distilled water at 37 ºC for no more than 21 days.

Gates Glidden and Largo Peeso nº 5 and 6 drills (Dentsply Maillefer, Tulsa, USA) were used to prepare the root canal for the fiberglass post cementation, at a depth of 12mm, delimited by a rubber stop. The residues were removed with distilled water irrigation.

- Experimental groups randomization and division

The roots were randomly allocated by lot in 8 different groups (n = 10), according to the reline of the post and the cementing technique (Table 2).

Table 2. Step-by-step description of experimental groups

Group	Description	Root treatment and post cementation
G1	Post + SBMP + ARC	The root dentin was etched with 32% phosphoric acid for 15 seconds, rinsed with distilled water for 15 seconds, and dried with paper cone; the Scotch Bond Multipurpose (SBMP) was applied with disposable brush and its excess removed with paper cone; the primer was applied (SBMP) with a disposable brush and its excess removed with paper cone; the catalyst was applied (SBMP) with a disposable brush and its excess removed

		with paper cone; the dual resin cement was inserted (Rely X ARC - ARC) into the root canal; the fiberglass post was inserted; and the assembly was photopolymerized for 40 seconds with LED light at 1400mW / cm^2 (Valo, Ultradent).
G2	Post + U200	The root dentin was cleaned with 0.5% sodium hypochlorite, rinsed with distilled water for 15 seconds, and dried with paper cone; the self - adhesive resin cement (Rely X U200 - U200) was inserted into the root canal; the fiberglass post was inserted; and the assembly was photopolymerized for 40 seconds with LED light at 1400mW / cm^2 (Valo, Ultradent).
G3	Post + SBU + Ultimate	The root dentin was cleaned with 0.5% sodium hypochlorite, rinsed with distilled water for 15 seconds;, and dried with paper cone; the universal adhesive (Single Bond Universal - SBU) was applied) with a disposable brush and its excess removed with paper cone; the dual resin cement (Rely X Ultimate – Ultimate) was inserted into the root canal; the fiberglass post was inserted; and the assembly was photopolymerized for 40 seconds with LED light at 1400mW / cm^2 (Valo, Ultradent).
G4	Post + All-in-one + NX3	The root dentin was cleaned with 0.5% sodium hypochlorite, rinsed with distilled water for 15 seconds, and dried with paper cone; the self-etching simplified adhesive (All-in-One - AIO) was applied with a disposable brush and its excess removed with paper cone; the dual resin cement (NX3) was inserted into the

		root canal; the fiberglass post was inserted; and the assembly was photopolymerized for 40 seconds with LED light at 1400mW / cm^2 (Valo, Ultradent).
G5	Relined post + SBMP + ARC	The same steps as G1 were done, except the relined post that it was only cleaned with phosphoric acid.
G6	Relined post + U200	The same steps as G2 were done, except the relined post that it was only cleaned with phosphoric acid.
G7	Relined post + SBU total-etch + Ultimate	The same steps as G3 were done, except the relined post that it was only cleaned with phosphoric acid.
G8	Relined post + All-in-one + NX3	The same steps as G4 were done, except the relined post that it was only cleaned with phosphoric acid.

All post groups followed the manufacturer treatment protocol, where the post was cleaned with alcohol and the silane was applied and dried for 45 seconds. The Scotchbond Multi-Purpose adhesive was then applied and photopolymerized for 20 seconds.

For the post relining, from group G5 to G8, the post was soaked with a composite resin, placed in position in the root canal and photopolymerized for 5 seconds, then the post and resin assembly were removed from the root canal and photopolymerized again for 40 seconds. The posts were then conditioned with 35% phosphoric acid for 20 seconds, washed and dried with an air jet.

Each group contained 10 representative specimens; and from each tooth could be made 2 or 3 discs for each region (cervical, middle or apical).

- Mechanical test of shear strength by extrusion (push-out)

After storage of the discs in 100% relative humidity at 37ºC for 24 hours, the shear strength test was performed by extrusion, following the thin discs push-out protocol. This method is more favorable for the uniformity of the data and allows to distinguish local differences of adhesion and also to reduce the number of teeth needed to make the specimens. [16]

Each group had specimens of the cervical, middle and apical region, and their cervical faces were marked with graphite. A stainless steel device containing a 5mm internal diameter hole in the central region was used to position each test body on the INSTRON universal test machine. The discs containing the fiberglass post were positioned exactly in the same direction as the hole in the metal baseplate, with the cervical side down so that the load was applied in the apex-coronal direction. A metal rod with 1.0 mm active tip diameter was attached to the machine grip and positioned in the center of the fiberglass post, and then a force of 50 kg was applied at a speed of 0.5 mm/min until fracture. The values obtained in kgf were multiplied by 0.0980655 which corresponds to the conversion factor of kgf to Newton and the area was calculated by the formula $A = 2\pi (R2 + R1) \times [h2 + (R2-R1)]\ 0.5$, where π is the 3.14 constant, h is the disc thickness, R2 is the post cervical portion radius, and R1 is the post apical portion radius. Then, the force in N was divided by the area found obtaining the values of extrusion resistance in MPa.[16,17]

- Failure mode analysis description

The samples, after the push-out test, were analyzed under an optical microscope and classified into one of the five failure modes: 1, adhesive failure between dentin and resin cement; 2, adhesive failure between resin cement and fiberglass post; 3, cohesive failure in resin cement; 4, cohesive failure in fiberglass post; and 5, mixed failure.

- Statistical analysis

After the exploratory and descriptive analysis, the data were transformed into square root to meet the assumptions of a parametric analysis. Variance analysis was applied in subdivided plots scheme, the plots being represented by the effects of the reline and cementing technique and the subplots represented by the radicular dentin region. All analyses were performed in the SAS, considering a 5% level of significance.

RESULTS

The results of the push-out can be seen in table 3.

Table 3. Mean (standard deviation) of extrusion shear strength (MPa) according to relining, cementation technique, and root dentin region.

Reline	**Technique**	**Root dentin region**		
		Cervical	**Middle**	**Apical**
Without	SBMP + ARC	*3,85(1,44)Aa	*2,43(0,76)ABa	1,78(1,02)Ba
	U200	4,30(1,20)Aa	3,17(1,33)ABa	1,60(1,00)Ba
	SBU total-etch + Ultimate	5,11(2,24)Aa	3,03(1,24)ABa	*2,04(1,11)Ba
	All-in-one + NX3	3,34(1,13)Aa	3,66(1,54)Aa	2,26(1,61)Aa
With	SBMP + ARC	6,70(0,79)Aa	6,06(1,10)Aa	3,34(0,78)Bab
	U200	5,13(1,24)Aa	5,13(1,46)Aa	3,42(1,72)Aab
	SBU total-etch + Ultimate	4,06(0,85)Aab	4,70(1,59)Aa	4,42(1,22)Aa
	All-in-one + NX3	2,46(0,92)Ab	2,38(1,11)Ab	2,48(2,05) Ab

* It differs from the groups without relining under the same conditions of technique and region ($p < 0.05$). Means followed by distinct letters (horizontal uppercase and

vertical lowercase comparing techniques within each relining condition) differ from each other (p <0.05).

From the table 3, it can be observed that in group 1 (SBMP + ARC) the cervical region showed greater resistance to shear by extrusion and statistical similarity with the middle region. However, the cervical region differed statistically from the apical region, which showed the lowest strength.

Group 2 (U200) demonstrated the greatest resistance to shear by extrusion also in the cervical region, being statistically similar to the middle region and different from the apical region that presented the lowest shear strength of the three regions, but did not present statistical difference when compared with the average.

Group 3 (SBU total-etch + Ultimate) showed statistical similarity in the cervical and middle region, being the cervical one that presented the greatest resistance by shear. The apical region in this group was statistically significantly different in relation to the other regions.

In group 4 (All-in-on + NX3) the three regions, cervical, middle and apical, did not present significant statistical difference, being the medium region with greater resistance to shear.

Group 5 (SBMP + ARC with relined post) showed statistical similarity between the cervical and middle regions. However, the apical region showed the lowest shear strength and statistical difference in relation to the other regions. In addition, the cervical and middle regions showed a statistical difference between the cervical and middle region from the group 1 mean (SBMP + ARC), which is the group without relining of the fiberglass post.

In group 6 (U200 with relined post), 7 (SBU total-etch + Ultimate with relined post) and 8 (All-in-one + NX3 with relined post) the three regions, cervical, middle and apical did not present a statistical significant difference between them, as there was no significant difference when comparing group 6 to group 2 and group 8 to group 4. Nevertheless, the apical region of group 7 showed a statistically significant difference in relation to the same region of group 3, which did not have relined post.

When comparing the cervical regions of the groups without relining (1, 2, 3 and 4), they did not show a statistical difference between them. The same occurred when we compared the middle and apical regions of these groups. The cervical region of groups 5, 6 and 7, were statistically similar, while the cervical region of group 8 showed lower shear strength than the other groups. The middle regions of the groups with relining were statistically similar to each other, with the exception of group 8, which showed lower shear strength. Finally, the apical regions of groups 5, 6 and 7 were statistically similar, with group 7 having the highest shear strength by extrusion, whereas group 8 showed lower strength among the groups with relining.

The failure mode is shown in figure 1.

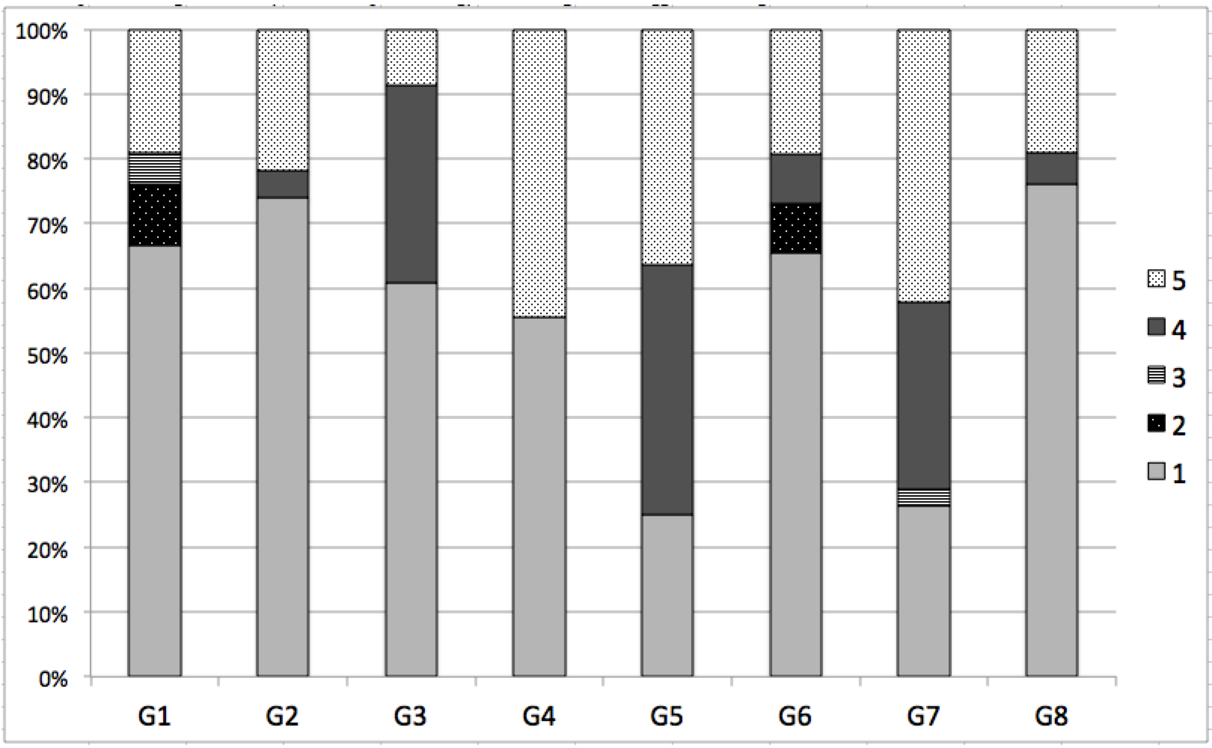

Figure 1. Failure mode distribution (%) between the groups observed by optical microscopy. AD, adhesive failure; MIX, mixed failure. 1, adhesive failure between dentin and resin cement; 2, adhesive failure between resin cement and fiberglass post; 3, cohesive failure in resin cement; 4, cohesive failure in fiberglass post; and 5, mixed failure.

The results will present a greater homogeneity in the groups without relining, with greater number of failures of type 1. However, the groups with relining show a greater heterogeneity, that is, the failure mode of type 1 even being in large quantity was not so prevalent when in G1 to G4.

DISCUSSION

This study evaluated the influence of the different cementation techniques of fiberglass posts relined or not with composite resin using different resin cements. Several adhesive systems were tested to establish a protocol with fewer steps, leading to a simplification of the Restorative Dentistry.

The first hypothesis that the use of a universal dentin adhesive system associated to a dual resin cement does not interfere in the extrusion resistance was partially accepted, since there was no statistical difference regarding the different cementing protocols without relining the fiberglass post, but among the groups with relining, the group 8 (All-in-one + NX3) has shown inferior results when compared to the others. The RelyX Arc + Adper Scotchbond Multi-Purpose groups have a protocol that uses acid etching. This type of adhesive is the oldest used in dentistry and depends on the formation of a hybrid layer through the infiltration of hydrophilic monomers after the demineralization of the superficial dentin by the acid etching.[18] However, universal adhesive systems can be used either with acid etching or as a self-etching.[8,9,19] In this study, Scotchbond Universal adhesive was used in groups 3 and 7, and the OptiBond All-in-One universal adhesive was used in groups 4 and 8 as a self-etching. Another technique for the simplification of the Restorative Dentistry is the use of the self-adhesive resin cements, thus eliminating the adhesive system step of the cementation protocol. These cements demineralize the dentin superficially without causing the formation of the hybrid layer, nor of the resin tags.[20, 21, 22] Therefore, in this study, groups 2 and 6 have in their protocol the self-adhesive cement RelyX U200. These results corroborate with the evidence from other studies that show there is no difference between the different cementation techniques using resin cements.[23, 24, 25] On the other hand, the unsatisfactory results of group 8 require further studies, since the literature is scarce in relation to the use of this type of protocol for fiberglass post cementation and there are no previous studies using this adhesive for intraradicular post cementation.

The second hypothesis, that the reline of the fiberglass post improves the extrusion resistance, was rejected. This is because this study has shown that there was no significant difference when compared the groups with or without relining of the intraradicular post using the same cementation protocol, with exception for groups 1 and 5 that showed a statistical difference in the cervical and middle region when compared and groups 3 and 7 in the apical region. However Rocha AT et al, it has shown that it perceives a difference when compared to groups with and without relining of the intraradicular post. Nevertheless, the literature says that there is a lot of divergence in the bond strength, depending on the methodology used.[27,28]

The main advantage of the post reline is the improvement in the adaption of the post to the root canal walls and reduction of the cement thickness used.[29] However, if there is no good adhesion quality at the dentin/adhesive interface, regardless of the cement thickness and the mechanical retention created, adhesive failure will occur in the disc push-out tests, but from G5 to G8 there was a smaller amount of this type of failure, therefore, it is speculated that even though not having such superior results in the push-out the groups with relining have a better adhesive quality at the interface dentin / adhesive, besides showing statistically similar in the three root regions, especially in the G7, which is suspected to be due to the homogeneity of the cement line due to the relining.

Finally, the third hypothesis, that the root dentin region interferes with the extrusion resistance, is valid for all groups without post relining and for the group 5, while the others did not present statistical differences between the different root regions. The data from this study has shown that the apical region had inferior resistance when compared to the cervical region, in agreement with the literature.[25,30,31,32] These results may be due to the restrict light access in the root apical region. In theory, dual resin cements should polymerize with or without light, but different from the self-curing resin cements the number of chemical initiators interferes with the working time of the double-cure cements.[25] Depending on the manufacturer, self-curing is limited, requiring light activation to have a better bond strength and mechanical properties after cementation.[33] Therefore, deeper regions are inaccessible to light compromising the monomers degree of conversion in the apical region and the properties of the resin cement.[30,32] Another reason for the apical region to have the lowest extrusion shear strength values in relation to the others is its morphology. In the apical region, the dentin is more disorganized and irregular in relation to the cervical, which can contribute to lower values, besides a poorer formation of the hybrid layer.[34]

CONCLUSION

Based on data from this *in vitro* study, the following conclusions were drawn:

01. The hypothesis that a universal dentin adhesive system associated with dual resin cement interferes with the extrusion resistance is false;
02. The reline of the fiberglass pin despite not presenting significant difference in the values of the push-out, but shows in the failure mode greater adhesive resistance;
03. The hypothesis that the root dentin region interferes with the extrusion resistance is true, with a difference between the regions and the apical one with the lowest values.

REFERENCES

1. Schwartz RS, Fransman R. Adhesive dentistry and endodontics: materials, clinical strategies and procedures for restoration of access cavities: a review. J Endod. 2005 Mar;31(3):151-65.

2. Faria e Silva AL, Arias VG, Soares LE, Martin AA, Martins LR. Influence of fiber-post translucency on the degree of conversion of a dual-cured resin cement. J Endod. 2007 Mar;33(3):303-5.

3. Faria-e-Silva AL, Moraes RR, Ogliari FA, Piva E, Martins LR. Panavia F: the role of the primer. J Oral Sci. 2009 Jun;51(2):255-9.

4. Piwowarczyk A, Bender R, Ottl P, Lauer HC. Long-term bond between dual-polymerizing cementing agents and human hard dental tissue. Dent Mater. 2007 Feb;23(2):211-7.

5. Zicari F, De Munck J, Scotti R, Naert I, Van Meerbeek B. Factors affecting the cement-post interface. Dent Mater. 2012 Mar;28(3):287-97.

6. Kim YK, Son JS, Kim KH, Kwon TY. A simple 2-step silane treatment for improved bonding durability of resin cement to quartz fiber post. J Endod. 2013 Oct;39(10):1287-90.

7. Leme AA, Pinho AL, de Gonçalves L, Correr-Sobrinho L, Sinhoreti MA. Effects of silane application on luting fiber posts using self-adhesive resin cement. J Adhes Dent. 2013 Jun;15(3):269-74.

8. Hanabusa M, Mine A, Kuboki T, Momoi Y, Van Ende A, Van Meerbeek B, De Munck J. Bonding effectiveness of a new 'multi-mode' adhesive to enamel and dentine. J Dent. 2012 Jun;40(6):475-84.

9. Muñoz MA, Luque I, Hass V, Reis A, Loguercio AD, Bombarda NH. Immediate bonding properties of universal adhesives to dentine. J Dent. 2013 May;41(5):404-11.

10. Chersoni S, Acquaviva GL, Prati C, Ferrari M, Grandini S, Pashley DH, Tay, FR. In vivo fluid movement through dentin adhesives in endodontically treated teeth. J Dent Res 2005; 84: 223-227.

11. Rueggeberg FA, Margeson DH. The effect of oxygen inhibition on na unfilled/filled composite system. J Dent Res. 1990 Oct;69(10):1652-8.

12. Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod 2010; 36(9)*:* 1543-6.

13. Grandini S, Goracci C, Monticelli F, Borracchini A, Ferrari M. SEM evaluation of the cement layer thickness after luting two different posts. J Adhes Dent. 2005 Autumn;7(3):235-40.

14. Aksornmuang J, Foxton RM, Nakajima M, Tagami J. Microtensile bond strength of a dual-cure resin core material to glass and quartz fiber posts. J Dent. 2004 Aug;32(6):443-50.

15. Marques EF, Bueno CE, Veloso HH, Almeida G, Pinheiro SL. Influence of instrumentation techniques and irrigating solutions on bond strength of glass fiber posts to rootdentin. Gen Dent. 2014 Mar-Apr;62(2):50-3.

16. Goracci C, Grandini S, Bossù M, Bertelli E, Ferrari M. Laboratory assessment of the retentive potential of adhesive posts: a review. J Dent. 2007 Nov;35(11):827-35.

17. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC, Tay F, Ferrari M. The adhesion between fiber posts and root canal walls: comparison between fiber posts and root canal walls: comparison between microtensile and push-out bondstrength measurements. Eur J Oral Sci. 2004 Aug;112(4):353-61.

18. Pashley DH, Tay FR, Breschi L, Tjäderhane L, Carvalho RM, Carrilho M,Tezvergil-Mutluay A. State of the art etch-and-rinse adhesives. Dent Mater. 2011 Jan;27(1):1-16. doi: 10.1016/j.dental.2010.10.016.

19. Kim RJ, Woo JS, Lee IB, Yi YA, Hwang JY, Seo DG. Performance of universaladhesives on bonding to leucite-reinforced ceramic. Biomater Res. 2015 May 22;19:11. doi: 10.1186/s40824-015-0035-1.

20. Bitter K, Paris S, Pfuertner C, Neumann K, Kielbassa AM. Morphological and bond strength evaluation of different resin cements to root dentin. Eur J Oral Sci. 2009 Jun;117(3):326-33. doi: 10.1111/j.1600-0722.2009.00623.x.

21. Ferracane JL, Stansbury JW, Burke FJ. Self-adhesive resin cements - chemistry,properties and clinical considerations. J Oral Rehabil. 2011 Apr;38(4):295-314. doi: 10.1111/j.1365-2842.2010.02148.x.

22. Monticelli F, Osorio R, Mazzitelli C, Ferrari M, Toledano M. Limited decalcification/diffusion of self-adhesive cements into dentin. J Dent Res. 2008 Oct;87(10):974-9.

23. Dimitrouli M, Geurtsen W, Lührs AK. Comparison of the push-out strength of two fiber post systems dependent on different types of resin cements. Clin Oral Investig. 2012 Jun;16(3):899-908. doi: 10.1007/s00784-011-0571-6.

24. Khalil AA, Abdelaziz KM. Bonding values of two contemporary ceramic inlay materials to dentin following simulated aging. *The Journal of Advanced Prosthodontics*. 2015;7(6):446-453. doi:10.4047/jap.2015.7.6.446.

25. Rodrigues RV, Sampaio CS, Pacheco RR, Pascon FM, Puppin-Rontani RM, Giannini M. Influence of adhesive cementation systems on the bond strength of relined fiber posts to root dentin. J Prosthet Dent. 2017 Oct;118(4):493-499. doi: 10.1016/j.prosdent.2017.01.006.

26. Rocha AT, Gonçalves LM, Vasconcelos AJC, Filho EMM, Carvalho CN, Tavarez RRJ, “Effect of Anatomical Customization of the Fiber Post on the Bond Strength of a Self-Adhesive Resin Cement,” International Journal of Dentistry, vol. 2017, Article ID 5010712, 6 pages, 2017. doi:10.1155/2017/5010712,

27. Mastoras K, Vasiliadis L, Koulaouzidou E, Gogos C. Evaluation of push-out bond strength of two endodontic post systems. J Endod. 2012 Apr;38(4):510-4. doi: 10.1016/j.joen.2011.12.039.

28. Pereira JR, Lins do Valle A, Ghizoni JS, Lorenzoni FC, Ramos MB, Dos Reis Só MV. Push-out bond strengths of different dental cements used to cement glass fiber posts. J Prosthet Dent. 2013 Aug;110(2):134-40. doi:10.1016/S0022-3913(13)60353-4.

29. Faria e Silva AL, Pedrosa-Filho Cde F, Menezes Mde S, Silveira DM, Martins LR. Effect of relining on fiber post retention to root canal. J Appl Oral Sci 2009; 17(6)*:* 600-4.

30. Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod. 2010 Sep;36(9):1543-6. doi: 10.1016/j.joen.2010.04.014.

31. Galhano GA, de Melo RM, Barbosa SH, Zamboni SC, Bottino MA, Scotti R.Evaluation of light transmission through translucent and opaque posts. Oper Dent.2008 May-Jun;33(3):321-4. doi: 10.2341/07-93.

32. Bahari M, Savadi Oskoee S, Kimyai S, Mohammadi N, Saati Khosroshahi E. Effect of Light Intensity on the Degree of Conversion of Dual-cured Resin

Cement at Different Depths with the use of Translucent Fiber Posts. J Dent (Tehran). 2014 May;11(3):248-55.

33. Faria-e-Silva AL, Fabião MM, Arias VG, Martins LR. Activation mode effects on the shear bond strength of dual-cured resin cements. Oper Dent. 2010 Sep-Oct;35(5):515-21. doi: 10.2341/10-051-L.

34. Tsurumachi T, Huang TJ, Zhan W, Hayashi M, Ogiso B. Scanning eléctron microscopic study of dentinal pulpal walls in relation to age and tooth area. J Oral Sci. 2008 Jun;50(2):199-203.

CONCLUSÃO

Baseado nos dados desse estudo *in vitro,* foram feitas as seguintes conclusões:

01. A hipótese de que um sistema adesivo dentinário universal associado ao cimento resino dual interfere na resistência à extrusão é falso;
02. O reembasamento do pino de fibra de vidro apesar de não apresentar diferença significativa nos valores do push-out, mostra no padrão de falha maior resistência adesiva;
03. A hipótese de que a região da dentina radicular interfere na resistência à extrusão é verídica, tendo diferença entre as regiões e sendo a apical a com os menores valores.

REFERÊNCIAS

1. Mannocci F, Cowie J. Restoration of endodontically treated teeth. Br Dent J.2014 Mar;216(6):341-6. doi: 10.1038/sj.bdj.2014.198.
2. Zorba YO, Erdemir A, Turkyilmaz A, Eldeniz AU. Effects of different curing units and luting agents on push-out bond strength of translucent posts. J Endod. 2010 Sep;36(9):1521-5. doi: 10.1016/j.joen.2010.04.026.
3. Cagidiaco MC, Goracci C, Garcia-Godoy F, Ferrari M. Clinical studies of fiber posts: a literature review. Int J Prosthodont. 2008 Jul-Aug;21(4):328-36.
4. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC,Tay F, Ferrari M. The adhesion between fiber posts and root canal walls:comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci. 2004 Aug;112(4):353-.
5. Faria e Silva AL, Arias VG, Soares LE, Martin AA, Martins LR. Influence offiber-post translucency on the degree of conversion of a dual-cured resin cement.J Endod. 2007 Mar;33(3):303-5.
6. Faria-e-Silva AL, Moraes RR, Ogliari FA, Piva E, Martins LR. Panavia F: the role of the primer. J Oral Sci. 2009 Jun;51(2):255-9.
7. Piwowarczyk A, Bender R, Ottl P, Lauer HC. Long-term bond betweendual-polymerizing cementing agents and human hard dental tissue. Dent Mater. 2007 Feb;23(2):211-7.
8. Zicari F, De Munck J, Scotti R, Naert I, Van Meerbeek B. Factors affecting the cement-post interface. Dent Mater. 2012 Mar;28(3):287-97.
9. Kim YK, Son JS, Kim KH, Kwon TY. A simple 2-step silane treatment for improved bonding durability of resin cement to quartz fiber post. J Endod. 2013 Oct;39(10):1287-90.
10. Leme AA, Pinho AL, de Gonçalves L, Correr-Sobrinho L, Sinhoreti MA. Effects of silane application on luting fiber posts using self-adhesive resin cement. J Adhes Dent. 2013 Jun;15(3):269-74.
11. Hanabusa M, Mine A, Kuboki T, Momoi Y, Van Ende A, Van Meerbeek B, De Munck J. Bonding effectiveness of a new 'multi-mode' adhesive to enamel and dentine. J Dent. 2012 Jun;40(6):475-84.

12. Muñoz MA, Luque I, Hass V, Reis A, Loguercio AD, Bombarda NH. Immediate bonding properties of universal adhesives to dentine. J Dent. 2013 May;41(5):404-11.

13. Chersoni S, Acquaviva GL, Prati C, Ferrari M, Grandini S, Pashley DH, Tay, FR. In vivo fluid movement through dentin adhesives in endodontically treated teeth. J Dent Res 2005; 84: 223-227.

14. Rueggeberg FA, Margeson DH. The effect of oxygen inhibition on an unfilled/filled composite system. J Dent Res 1990; 69: 1652-8.

15. Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod 2010; 36(9): 1543-6.

16. Grandini S, Goracci C, Monticelli F, Borracchini A, Ferrari M. SEM evaluation of the cement layer thickness after luting two different posts. J Adhes Dent. 2005 Autumn;7(3):235-40.

17. Aksornmuang J, Foxton RM, Nakajima M, Tagami J. Microtensile bond strength of a dual-cure resin core material to glass and quartz fiber posts. J Dent. 2004 Aug;32(6):443-50.

APÊNDICE 1 – MATERIAIS E MÉTODOS

O experimento foi em esquema fatorial de parcelas subdivididas (região cervical, médio e apical). Os fatores de estudo foram: 1) reembasamento com resina composta, em 2 níveis; 2) técnica de cimentação, em 4 níveis; 3) região da dentina radicular, em 3 parcelas. A variável resposta foi: 1) resistência ao cisalhamento por extrusão (MPa).

Materiais usados na pesquisa estão detalhados na tabela 1.

Tabela1. Materiais utilizados neste estudo.

Material	**Composição**	**Fabricante**
Pino	Fibra de vidro e resina epóxica	Exacto, Angelus, Londrina, Brasil
Resina composta	BisGMA, BisEMA e UDMA, Partículas: sílica/zircônia, Fotoiniciador	Filtek Z250XT, 3M ESPE, St Paul, EUA
Adesivo	Solução de BisGMA, HEMA e fotoiniciador	Scotchbond Multi-Purpose, 3M ESPE, St Paul, EUA
Silano	Silano pré-hidrolizado	Rely X Ceramic Primer, 3M ESPE, St Paul, EUA
Ácido fosfórico	Ácido fosfórico 35%, espessante	Ultra-etch, Ultradent, South Jordan, EUA
Primer	Solução aquosa de HEMA e copolímero de ácido polialcenóico	Scotchbond Multi-Purpose, 3M ESPE, St Paul, EUA

Ativador	Sal de ácido sulfínico, etanol e fotoiniciador	Scotchbond Multi-Purpose, 3M ESPE, St Paul, EUA
Catalisador	Bis-GMA, HEMA e peróxido de benzoíla	Scotchbond Multi-Purpose, 3M ESPE, St Paul, EUA
Adesivo	MDP, copolímero de ionômero de vidro, silano e fotoiniciador	Single Bond Universal, 3M ESPE, St Paul, EUA
Adesivo	GPDM, co-monômeros incluindo monômero metacrilatos mono e disduncinal, nano-sílica, fotoiniciador	OptiBond All-in-one, Kerr Corporation, Orange, USA
Cimento resinoso dual	Pasta A: BisGMA, TEGDMA, partículas de sílica e zircônia, pigmentos, aminas e fotoiniciadores Pasta B: Bis-GMA, TEGDMA, peróxido de benzoíla e partículas de sílica e zircônia	RelyX ARC, 3M ESPE, St Paul, EUA
Cimento resinoso dual	Pasta A: Pó de vidro tratado com silano, ácido 2-propenóico, 2-metil-, 1,1- [1-(hidroximetil) -1, 2-etanodiil] éster, produtos da reacção com 2-hidroxi-1,3-propanodiilo e DMA óxido de fósforo, TEGDMA, sílica tratada com silano, óxido de produtos químicos de vidro, persulfato de sódio, terc-butil-peroxi-3,5,5-trimetil, cobre (II) mono-hidrato de acetato	RelyX Ultimate, 3M ESPE, St Paul, EUA

	Pasta B: Pó de vidro tratado com silano, DMA substituído, DMA 1,12-dodecano, sílica tratada com silano, 1-benzil-5-phenylbarbic-ácido, sal de cálcio, p-toluenesulfinate de sódio, ácido 2-propenóico, 2-metil-, éster de[(3-metoxypropyl) imino] di-2,1-etanodiilo, hidróxido de cálcio, dióxido de titânio	
Cimento resinoso dual	Pasta base: monómeros de metacrilato contendo grupos de ácido fosfórico, monómeros de metacrilato, carga silanada, componentes iniciadores, estabilizadores, aditivos reológicos Pasta catalisadora: monómeros de metacrilato, cargas alcalinas (básicas), carga silanadas, componentes iniciadores, estabilizadores, pigmentos, aditivos reológicos	RelyX U200, 3M ESPE, St Paul, EUA
Cimento resinoso dual	Uncured Methacrylate Ester Monomers, non-hazardous inert mineral fillers, non-hazardous activators and stabilizers and radiopaque agent	NX3 Nexus Third Generation, Kerr Corporation, Orange, USA

BisGMA: bisfenol-A-glicidil dimetacrilato; BisEMA: bisfenol-A-glicidil dimetacrilato etoxilado; UDMA: uretano dimetcrilato; TEGDMA: trietilenoglicol dimetacrilato; HEMA: hidroxietil dimetacrilato; GPDM: glicero fosfato dimetacrilato.

- Confecção dos corpos de prova

Dentes bovinos com anatomia radicular reta, ápice fechado e livre de trincas foram selecionadas previamente e limpas e desinfeccionadas em solução de timol a 0,5%. Foram utilizadas 80 raízes seccionadas com disco, na cortadeira, no comprimento de 18mm (Figura 1 e 2). A polpa foi removida com limas tipo K (Dentsply-Maillefer, Tulsa, EUA) e irrigação com hipoclorito de sódio a 1,0% para suspensão da matéria orgânica. As raízes foram numeradas para posterior randomização e armazenadas em água destilada a 37ºC.

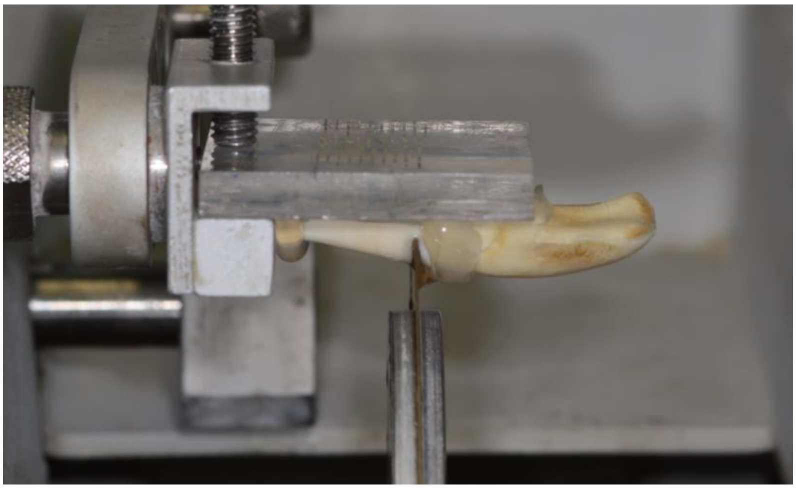

Figura 1. Secção do dente bovino em 18mm.

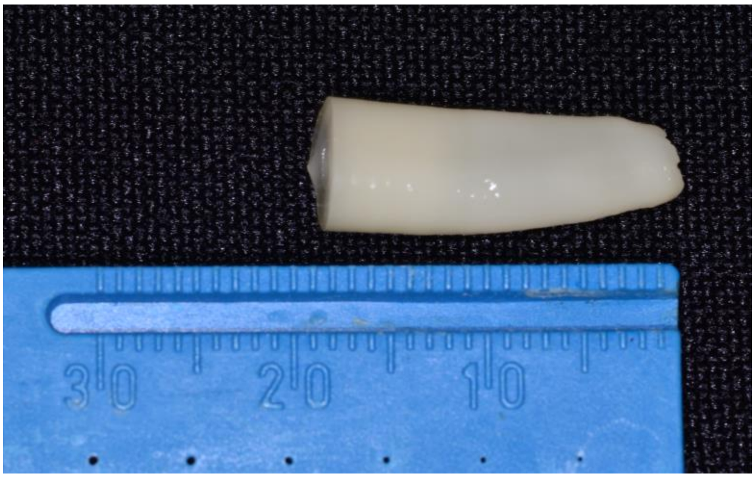

Figura 2. Conferência do comprimento da raiz em 18 mm.

O tratamento endodôntico foi realizado manualmente com instrumentação mecânica com limas K (Dentsply Maillefer, Tulsa, EUA) em comprimento de trabalho de 17mm, e batente apical realizado com a lima 40. Durante o processo de instrumentação, o conduto radicular foi abundantemente irrigada com água destilada, para que a solução irrigadora não caracterize um fator de confundimento ao estudo (figura 3 – a,b). A obturação do conduto radicular foi realizada com cones de guta-percha e cimento endodôntico Sealer 26 (Dentsply, Tulsa, EUA) (figura 4). Então, as raízes serão armazenadas em água destilada a 37ºC por não mais do que 21 dias.

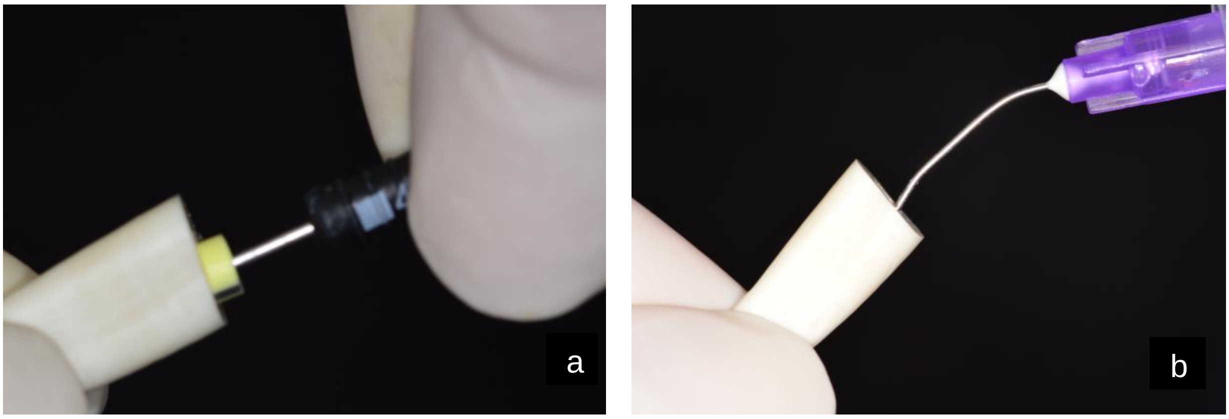

Figura 3. a) instrumentação do canal radicular com limas do tipo K; b) irrigação para remoção de depris.

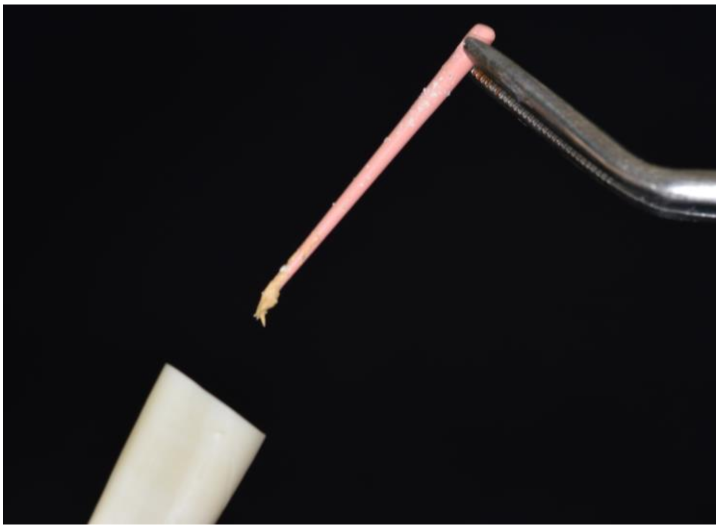

Figura 4. Cimentação do cone de guta-percha com cimento endodôntico.

Brocas Gates Glidden e Largo Peeso nº 5 e 6 (Dentsply Maillefer, Tulsa, EUA) foram utilizadas para o preparo do conduto radicular para a cimentação do pino de fibra de vidro, na profundidade de 12mm (figura 5), delimitada por um stop de borracha. Os debris serão removidos com irrigação de água destilada.

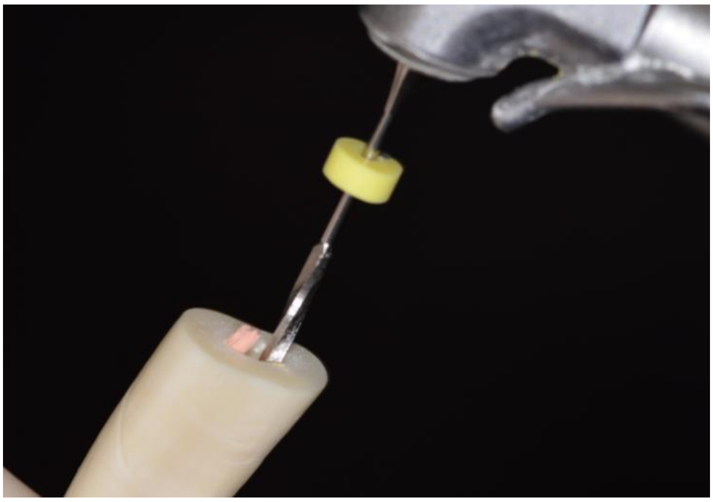

Figura 4. Preparo do conduto radicular em 12 mm para cimentação do pino de fibra de vidro.

- Randomização e divisão dos grupos experimentais

As raízes foram alocadas aleatoriamente por meio de sorteio em 8 grupos diferentes (n=10), de acordo com o reembasamento do pino e a técnica de cimentação (Tabela2).

Tabela2. Descrição do passo a passo dos grupos experimentais

Grupo	Descrição	Tratamento da raíz e cimentação do pino
G1	Pino + SBMP + ARC	Condicionamento com ácido fosfórico a 32% por 15 segundos da dentina radicular; lavagem com água destilada por 15 segundos; secagem com cone de papel; aplicação do ativador (Scotch Bond Multipurpose – SBMP) com pincel descartável e remoção do seu excesso com cone de papel; aplicação do primer (SBMP) com pincel descartável e remoção do seu excesso com cone de papel; aplicação do catalisador

		(SBMP) com pincel descartável e remoção do excesso com cone de papel; inserção do cimento resinoso dual (Rely X ARC – ARC) no interior do conduto radicular; inserção do pino de fibra de vidro previamente tratado com silano; fotopolimerização do conjunto por 40 segundos com luz LED a 1400mW/cm^2 (Valo, Ultradent).
G2	Pino + U200	Limpeza da dentina radicular com hipoclorito de sódio 0,5%, lavagem com com água destilada por 15 segundos; secagem com cone de papel; inserção do cimento resinoso autoadesivo (Rely X U200 – U200) no interior do conduto radicular; inserção do pino de fibra de vidro previamente tratado com silano; fotopolimerização do conjunto por 40 segundos com luz LED a 1400mW/cm^2 (Valo, Ultradent).
G3	Pino + SBU + Ultimate	Limpeza da dentina radicular com hipoclorito de sódio 0,5%; lavagem com com água destilada por 15 segundos; secagem com cone de papel; aplicação do adesivo universal (Single Bond Universal - SBU) com pincel descartável e remoção do excesso com cone de papel; inserção do cimento resinoso dual (Rely X Ultimate – Ultimate) no interior do conduto radicular; inserção do pino de fibra de vidro previamente tratado com silano; fotopolimerização do conjunto por 40 segundos com luz LED a 1400mW/cm^2 (Valo, Ultradent).
G4	Pino + All-in-one + NX3	Limpeza da dentina radicular com hipoclorito de sódio 0,5%; lavagem com com água destilada por 15 segundos; secagem com cone de papel; aplicação do adesivo autocondicionante simplificado (All-in-One - AIO) com pincel descartável e remoção do excesso com cone de papel; inserção do cimento resinoso dual (NX3)

		no interior do conduto radicular; inserção do pino de fibra de vidro previamente tratado com silano; fotopolimerização do conjunto por 40 segundos com luz LED a 1400mW/cm^2 (Valo, Ultradent).
G5	Pino reembasado + SBMP + ARC	Da mesma maneira que G1, exceto pelo pino reembasado que será somente limpo com ácido fosfórico.
G6	Pino reembasado + U200	Da mesma maneira que G2, exceto pelo pino reembasado que será somente limpo com ácido fosfórico.
G7	Pino reembasado + SBU total-etch + Ultimate	Da mesma maneira que G3, exceto pelo pino reembasado que será somente limpo com ácido fosfórico.
G8	Pino reembasado + All-in-one + NX3	Da mesma maneira que G4, exceto pelo pino reembasado que será somente limpo com ácido fosfórico.

Todos os grupos seguiram o protocolo de tratamento do pino de fibra de vidro de acordo com o fabricante, em que o pino foi limpo com álcool, aplicado de silano e seco por 45 segundos. O adesivo Scotchbond Multi-Purpose foi aplicado e fotoativado por 20 segundos (figura 5).

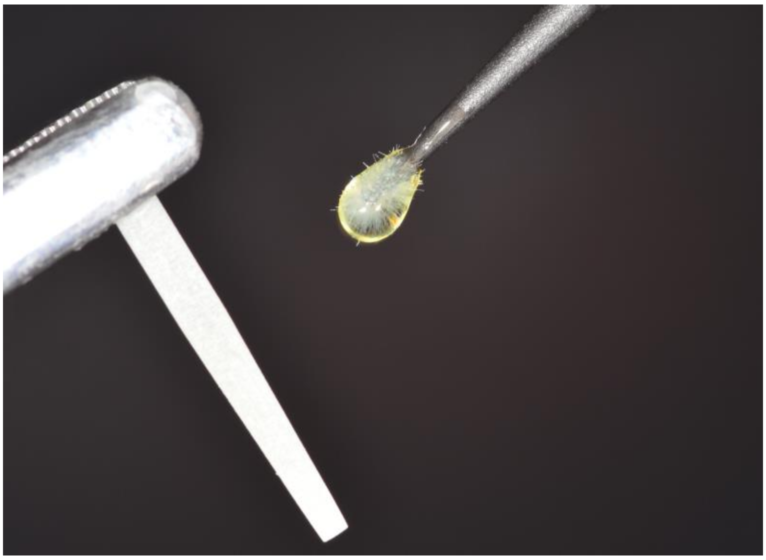

Figura 5. Protocolo de tratamento do pino de fibra de vidro.

Para o reembasamento do pino, nos grupos de G5 a G8, o pino foi embebido com a resina composta, colocado em posição no conduto radicular e fotopolimerizada por 05 segundos, depois o conjunto pino e resina foi removido do canal e fotoativado novamente durante 40 segundos. Em seguida, os pinos foram condicionados com ácido fosfórico 35% por 20 segundos, lavados e secos com jato de ar (figura 6 – a, b, c, d).

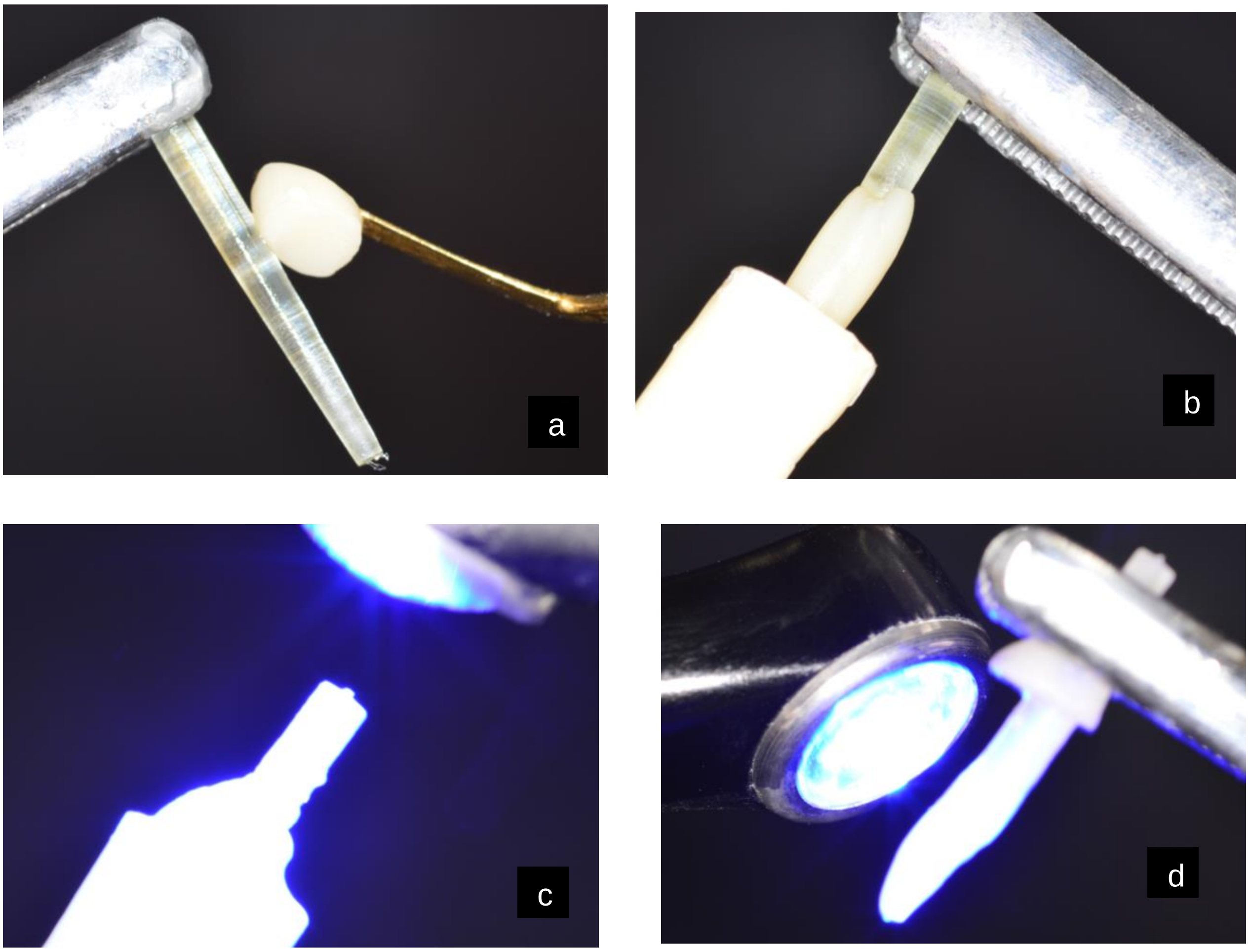

Figura 6. a) Pino embebido em resina composta; b) Colocação em posição no conduto radicular; c) fotoativação por 05 segundos e remoção do conduto, e; d) fotoativação por 40 segundos.

Cada grupo contém 10 amostras representativas; e de cada dente foi confeccionado de 2 a 3 discos para cada região (cervical, médio ou apical) (figura 7).

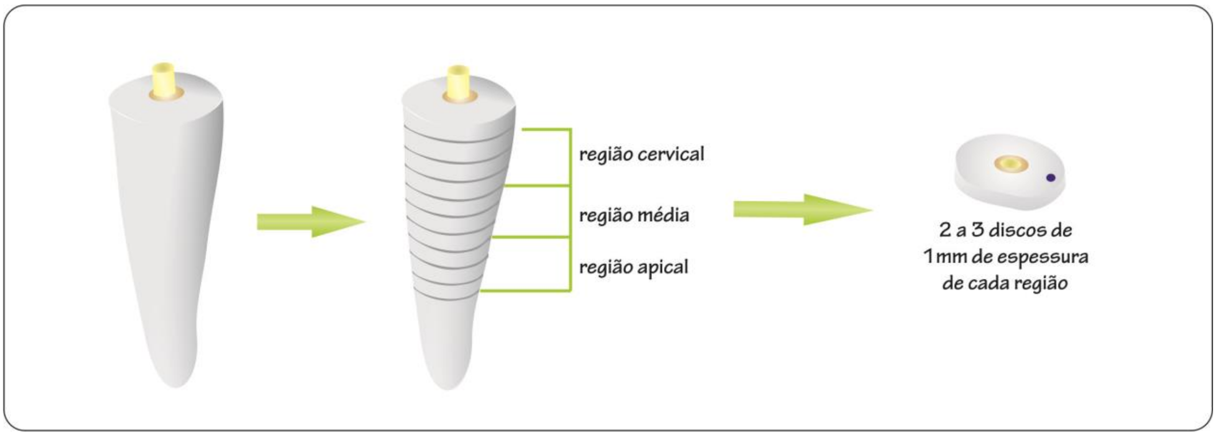

Figura7. Esquema representando a obtenção dos corpos de prova.

- Ensaio mecânico de resistência ao cisalhamento por extrusão (push-out)

Após armazenamento dos discos em 100% de umidade relativa a 37ºC por 24 horas, foi realizado o teste de resistência ao cisalhamento por extrusão, seguindo o protocolo de push-out de discos finos.

Cada grupo teve espécimes da região cervical, médio e apical e a face cervical de cada um deles foi marcado com grafite. Um dispositivo em aço inoxidável, contendo um orifício de 5mm de diâmetro interno na região central, foi usado para posicionar cada corpo de prova na máquina de ensaio universal INSTRON (figura 8). Os discos contendo o pino de fibra de vidro foram posicionadas exatamente na mesma direção do orifício da base metálica, com o lado cervical para baixo para que a carga seja incidida no sentido ápice-coronal. Uma haste metálica com ponta ativa de 1,0 mm de diâmetro foi fixada no mordente da máquina e posicionada no centro do pino de fibra de vidro e incidida uma força de 50kg numa velocidade de 0,5 mm/min, até a fratura (figura 9). Os valores obtidos em kgf foram multiplicados por 0,0980655 que corresponde ao fator de conversão de kgf para Newton e a área será calculada pela fórmula $A = 2\pi(R2+R1) \times [h^2 + (R2-R1)]^{0,5}$, onde π é a constante 3,14 e h é a espessura do disco e R2 é o raio que corresponde a porção coronal do pino e R1 é o raio da porção apical do pino. Em seguida, a força em N foi dividida pela área encontrada obtendo-se os valores de resistência à extrusão em MPa.

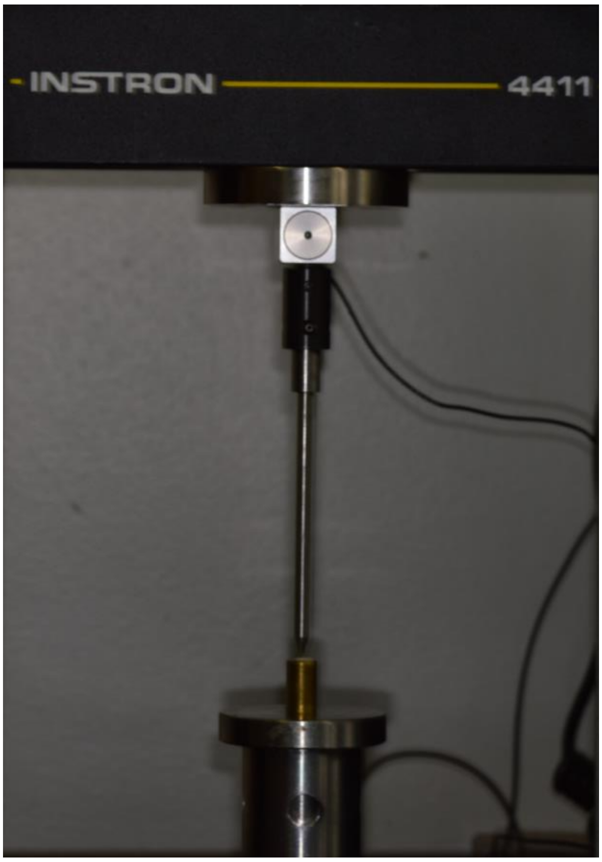

Figura 8. Máquina ensaio universal INSTRON.

Figura 9. Força incidida até a fratura do disco.

- Descrição da análise de padrão de falha

As amostras, após o push-out, foram analisadas em microscópio óptico para classificação dos padrões de falha: 1) falha adesiva entre dentina e cimento resinoso; 2) Falha adesiva entre cimento resinoso e pino de fibra de vidro; 3) Falha coesiva no cimento resinoso; 4) Falha coesiva no pino de fibra de vidro e; 5)Falha mista.

- Análise estatística

Após a análise exploratória e descritiva os dados foram transformados em raiz quadrada para atenderem as pressuposições de uma análise paramétrica. Foi aplica análise de variância em esquema de parcelas subdivididas, sendo as parcelas representadas pelo efeitos do reembasamento e técnica de cimentação e as subparcelas pela região da dentina radicular. Todas as análises foram realizadas no SAS, considerando o nível de significância de 5%.

ANEXO 1

Comprovação de submissão para Operative Dentistry:

Operative Dentistry | 6559_0_merged_151568

jopdent.allentrack.net/cgi-bin/main.plex?el=A6DR3CWH4A2ENt3R6B9ftdkckVvM2reRrknVqzpoCpmAZ&amt=35.00&cc=USD&cm=el_eq_A2DR4CWH4A1ENt4U3B9ftdeXDqVdgwsiq...

Please print this page for your records. This is a receipt of the uploaded files.

Manuscript Number: 18-011-L
Manuscript Title: EVALUATION OF THE INFLUENCE OF RELINING WITH COMPOSITE RESIN AND USE OF UNIVERSAL ADHESIVE ON THE SHEAR RESISTANCE PER PUSH-OUT OF FIBERGLASS INTRARADICULAR POSTS
Abstract: This study was to evaluate the effects of relining with composite resin and different protocols on the extrusion resistance of fiberglass posts, through a controlled and randomized experimental study. The study factors were: 1) cementing technique, in 4 levels: G1 and G5: Scoth Bond Multi-Purpose (SBMP) + RelyX ARC (ARC); G2 and G6: RelyX U200 (U200); G3 and G7: Single Bond Universal (SBU) self-etch + RelyX Ultimate (Ultimate); G4 and G8: OptiBond All-in-one self-etch + NX3 Nexus Third Generation (NX3), e; 2) composite resin reline, in 2 levels: G1 to G4 without relining and G5 to G8 with relining of the post, and; 3) radicular dentin region, in 3 plots: cervical, middle and apical region. So, 2 or 3 discs were made for each region root region. The specimens were tested for shear strength by push-out until fracture using the universal test machine INSTROM. After, the samples were analyzed under an optical microscope to classify the failure modes. The results were found to have not been statistical difference between different cementation protocols without relining of the fiberglass post, but among the groups with relining, group 8 had the lowest values. There was no significant difference between the groups with or without relining of the fiberglass post when the same cementation protocol was applied, except for the groups 1 and 5 in the cervical and middle region and groups 3 and 7 in the apical region. However, the root dentin region has shown to interfere in the extrusion resistance in the groups without post relining and in the group 5. Already, the failure modes showed a homogeneity and more adhesive failures in the groups without relining, whereas in the reline groups the failures were more heterogeneous. Therefore, the hypothesis that a universal dentin adhesive system associated with dual resin cement interferes with the push-out is false. The reline of the fiberglass post although not presenting significant difference in the values of the push-out, shows in the failure modes better adhesive strength. Finally, the hypothesis that the root dentin region interferes with the extrusion resistance is true, with a difference between the regions and the apical one with the lowest values.
Create Date: 2018-01-11 09:32:31

Uploaded file information:

File Name	Title	Description	Format
	Electronic Copyright Form for Marina Faria		html
	Article File, References, and/or Figure/Table Legend	Article File, References, and/or Figure/Table Legend	docx
	Figure 1	Figure	docx
	Table 1		docx
	Table 2		docx
	Table 3		docx

Submission Payment Due: $35.00
Submission Payment Received: $0.00
(Submission Payment still currently pending at PayPal.)

Continue

Operative Dentistry

jopdent.allentrack.net/cgi-bin/main.plex?form_type=status_details&j_id=173&ms_id=6559&ms_rev_no=0&ms_id_key=ftdnFd0HUx84BBiq2clHDhJg

Detailed Status Information

Manuscript #	18-011-L
Current Revision #	0
Submission Date	2018-01-11
Current Stage	Editorial Office Processing
Title	EVALUATION OF THE INFLUENCE OF RELINING WITH COMPOSITE RESIN AND USE OF UNIVERSAL ADHESIVE ON THE SHEAR RESISTANCE PER PUSH-OUT OF FIBERGLASS INTRARADICULAR POSTS
Running Title	EVALUATION OF THE INFLUENCE OF RELINING WITH COMPOSITE RESIN AND USE OF UNIVERSAL ADHESIVE ON THE SHEAR RESISTANCE PER PUSH-OUT OF FIBERGLASS INTRARADICULAR POSTS
Manuscript Type	Laboratory Research
Corresponding Author	Marina Faria (Faculdade de Odontologia de Piracicaba)
Contributing Author	N/A
Financial Disclosure	I have no relevant financial interests in this manuscript.
Abstract	This study was to evaluate the effects of relining with composite resin and different protocols on the extrusion resistance of fiberglass posts, through a controlled and randomized experimental study. The study factors were: 1) cementing technique, in 4 levels: G1 and G5: Scoth Bond Multi-Purpose (SBMP) + RelyX ARC (ARC); G2 and G6: RelyX U200 (U200); G3 and G7: Single Bond Universal (SBU) self-etch + RelyX Ultimate (Ultimate); G4 and G8: OptiBond All-in-one self-etch + NX3 Nexus Third Generation (NX3), e; 2) composite resin reline, in 2 levels: G1 to G4 without relining and G5 to G8 with relining of the post, and; 3) radicular dentin region, in 3 plots: cervical, middle and apical region. So, 2 or 3 discs were made for each region root region. The specimens were tested for shear strength by push-out until fracture using the universal test machine INSTROM. After, the samples were analyzed under an optical microscope to classify the failure modes. The results were found to have not been statistical difference between different cementation protocols without relining of the fiberglass post, but among the groups with relining, group 8 had the lowest values. There was no significant difference between the groups with or without relining of the fiberglass post when the same cementation protocol was applied, except for the groups 1 and 5 in the cervical and middle region and groups 3 and 7 in the apical region. However, the root dentin region has shown to interfere in the extrusion resistance in the groups without post relining and in the group 5. Already, the failure modes showed a homogeneity and more adhesive failures in the groups without relining, whereas in the reline groups the failures were more heterogeneous. Therefore, the hypothesis that a universal dentin adhesive system associated with dual resin cement interferes with the push-out is false. The reline of the fiberglass post although not presenting significant difference in the values of the push-out, shows in the failure modes better adhesive strength. Finally, the hypothesis that the root dentin region interferes with the extrusion resistance is true, with a difference between the regions and the apical one with the lowest values.
Associate Editor	Not Assigned
Key Words	Adhesives, Dental Cements, Shear Strength
Topic	ADHESIVE BONDING, RESTORATION OF ENDODONTICALLY TREATED TEETH
Clinical Relevance	I declare that the article is clinically relevant since it aims to simplify and improve the fiberglass post cementation protocols.
Copyright Release Date	Not Received